

**WHAT IS CLAIMED IS:**

1. A message-passing decoder for low-density parity-check (LDPC) codes, which is for decoding block codes encoded with LDPC codes by a message-passing decoding algorithm, the message-passing decoder comprising:

a log likelihood ratio calculator for receiving a code word having a consecutive value from block codes encoded with the LDPC codes, and calculating a log likelihood ratio;

a bit node function unit for calculating a bit message using the log likelihood ratio calculated by the log likelihood ratio calculator and an input parity-check message;

a check node function unit for calculating the parity-check message using the bit message calculated by the bit node function unit, and outputting the calculated parity-check message to the bit node function unit; and

a parity checker for receiving a code word decoded by the bit node function unit from the final parity-check message calculated by a repeated decoding of the bit node function unit and the check node function unit, and checking a parity,

wherein the parity-check message corresponding to a logic function output for an input from the bit node function unit is calculated according to a linear approximation function determined for each divided interval of the logic function.

2. The message-passing decoder as claimed in claim 1, wherein the

check node function unit comprises:

a multiplier for multiplying the input from the bit node function unit by a slope of the linear approximation function for each interval;

a summator for adding a boundary value of the linear approximation function for each interval to an output value of the multiplier; and

a multiplexor for selecting an output of the summator according to an interval range of the input.

3. The message-passing decoder as claimed in claim 1, wherein the check node function unit comprises:

a slope calculator for calculating a slope, to be multiplied, from a bit of the highest order other than “0” in the input from the bit node function unit, and multiplying the slope with a bit shifter and a summator;

a boundary calculator for calculating a boundary value of the linear approximation function for each interval from the bit of the highest order other than “0” in the input; and

a summator for adding the boundary value calculated by the boundary calculator to an output of the slope calculator.

4. The message-passing decoder as claimed in claim 3, wherein the slope calculator comprises:

a bit shifter for shifting each bit of the input to the left or right side so as to construct the slope;

a ground for expressing a value of “0” used in the calculation of the

slope;

a word negater for inverting an output of the bit shifter by each word sign to express the slope; and

a switch for combining the outputs of the word negater and the ground to output a final result.

5. The message-passing decoder as claimed in claim 4, wherein the boundary calculator comprises:

a bit shifter for shifting each bit of the input to the left or right side so as to construct the boundary value;

a ground for expressing a value of “0” used in the calculation of the boundary value;

a word negater for inverting an output of the bit shifter by each word sign to express the boundary value; and

a switch for combining the outputs of the word negater and the ground to output a final result.

6. The message-passing decoder as claimed in claims 1, wherein the logic function  $\Phi(x)$  satisfies the following equation:

$$\Phi(x) = -\log\left(\tanh\left(\frac{|x|}{2}\right)\right)$$

wherein x is the input from the bit node function unit.

7. The message-passing decoder as claimed in claim 6, wherein the

interval  $I_i$  of the linear approximation is determined by the following equation:

$$I_i = [2^{K+i} 2^{K+1+i}], \quad i \in \{0, \dots, n_1 - 1\}, \quad K = -n_2$$

wherein  $n_1$  is the length of a word expressing the input, i.e., a word length; and  $n_2$  is the bit corresponding to a minimum resolution of decimal places expressing the input,

the boundary value on either side of the interval being the power of 2.

8. The message-passing decoder as claimed in claim 7, wherein the linear approximation function  $y$  satisfies the following equation:

$$y = s_i r + x_i, \quad i \in \{0, \dots, |I_i| - 1\}, \quad r \in I_i,$$

wherein  $s_i$  is the slope; and  $x_i$  is the boundary value.

9. The message-passing decoder as claimed in claim 8, wherein the slope  $s_i$  satisfies the following equation:

$$s_i = \text{ROUND} \left( \frac{\Phi(2^{K+n_1-i-1}) - \Phi(2^{K+n_1-i})}{2^{K+n_1-i-1} - 2^{K+n_1-i}}, \quad n_2 \right), \quad i \geq 0$$

wherein the ROUND function is a function for designating the input as the most approximate one of binary numbers given by  $2^{-n_2}$  as the minimum resolution,

the ROUND function satisfying the following equation:

$$\text{ROUND}(x, \quad n_2) = 2^{-n_2} \left\lfloor \frac{x}{2^{-n_2}} + \frac{1}{2} \right\rfloor$$

10. The message-passing decoder as claimed in claim 9, wherein the

boundary value  $x_i$  satisfies the following equation:

$$x_i = \text{ROUND}\left(\left(2^{K+n_1-i} - 2^{K+n_1-i+1}\right)s_i + x_{i-1}, n_2\right), \quad i \geq 1,$$

$$x_0 = \text{ROUND}\left(\Phi\left(2^{K+n_1}\right), n_2\right)$$